[SPECIFICATION]

[TITLE OF THE INVENTION]

MULTI-DOMAIN LIQUID CRYSTAL DISPLAY DEVICE

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is sectional view of pixel unit of the conventional liquid crystal display device;

FIGS. 2a and 2b are plan views showing a unit pixel of a multi-domain liquid crystal display device according to the present invention;

FIGS. 3a and 3b are sectional views showing a multi-domain liquid crystal display device, taken along lines I-I′ and II-II′ of FIG. 2b;

FIGS. 4a to 4e are sectional views showing a method for fabricating a multi-domain liquid crystal display device, taken along lines III-III′ of FIG. 2a;

FIGS. 5a to 5c are plan views showing a multi-domain liquid crystal display device according to the first embodiment of the present invention;

FIGS. 6a to6 are plan views showing a multi-domain liquid crystal display device according to the second embodiment of the present invention;

FIGS. 7a to 7c are plan views showing a multi-domain liquid crystal display device according to the third embodiment of the present invention;

FIGS. 8a to 8c are plan views showing a multi-domain liquid crystal display device according to the fourth embodiment of the present invention;

FIGS. 9a to 9c are plan views showing a multi-domain liquid crystal display device according to the fifth embodiment of the present invention;

FIGS. 10a to 10c are plan views showing a multi-domain liquid crystal display device according to the sixth embodiment of the present invention; and,

FIGS. 11a to 11j are sectional views showing a multi-domain liquid crystal

display device according to the present invention.

Reference numerals of the essential parts in the drawings

1: gate bus lines	3: data bus lines
5: semiconductor layer	6: ohmic contact layer
7: source electrode	9: drain electrode
11: gate electrode	13: pixel electrode
15: common auxiliary electrode	17: common electrode
23: color filter layer	25: light-shielding layer
29: uniaxial phase difference film	31: first substrate
33: second substrate	35: gate insulating film
37: passivation film	39: contact hole
43: storage electrode	47: liquid crystal
51: electric field induction window	
53: dielectric structure	
59: biaxial phase difference film	
71: polarizer	

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The present invention relates to a liquid crystal display device, and more particularly, to a multi-domain liquid crystal display device in which a common auxiliary electrode is formed around and in a pixel region on a same layer as a gate line, and at least one or more electric field induction windows which distort an electric field and dielectric structures are formed in the pixel region.

Recently, a liquid crystal display (LCD) has been proposed where the liquid

crystal is not aligned and the liquid crystal is driven by common-auxiliary electrodes insulated from pixel electrodes. FIG. 1 is sectional view of pixel unit of the conventional LCDs.

The related art LCDs is structured by including a first and a second substrates, a plurality of data bus lines 132 and gate bus 131B lines, each of which is arranged in a vertical direction and a horizontal direction, respectively, on the first substrate, for dividing the first substrate into a plurality of pixel regions, a thin film transistor (TFT) formed on each pixel region and includes a gate electrode, a gate insulator, a semiconductor layer, ohmic contact layer and a source and/or a drain electrodes, a passivation film formed over the whole first substrate, and a part of pixel electrode formed on the passivation film to be connected with the drain electrode.

The related art further includes a color filter layer formed on the second substrate, a common electrode formed on the color filter layer and a liquid crystal layer formed between the first and second substrates. Furthermore, a dielectric projection 120A is formed on the pixel electrode in a zig-zag form, and a dielectric projection 120B is formed on the color filter layer in a formation similar to the dielectric projection 120A and is parallel to the dielectric projection 120A. Also, a light-shielding layer 25 is formed on a bending portion or a corner portion of the gate lines, the data lines, the thin film transistor and the dielectric projections 120A and 120B, so that light leaked therefrom is blocked.

The dielectric projections 120A and 120B divide the pixel region, and induce and distort the electric field applied to the liquid crystal layer, so as to drive the liquid particles in every direction. This means that dielectric energy due to the distorted electric field orients a liquid crystal director in a desired direction when a voltage is applied to the liquid crystal display device.

However, the liquid crystal display device has several problems. The dielectric projections 120A and 120B can obtain multi-domain effect, but reduce aperture ratio. To solve this problem, the dielectric projections are formed with narrow widths. However, the thick light-shielding layer formed to prevent shadow from being generated at the bending or corner portion of the dielectric projections still causes problems related to aperture ratio.

Moreover, if the dielectric projections are not formed or if they have quite small widths, the distortion range of the electric field required to divide the domain is weak. Accordingly, there is a problem that the time it takes to orient the liquid crystal and to reach a stable state is increased.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

Accordingly, the present invention is directed to a multi-domain liquid crystal display device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a multi-domain liquid crystal display device in which a common auxiliary electrode is formed around and in a pixel region on the same layer as a gate line, and at least one or more electric field induction windows and dielectric structures, which are distorting the electric field accompanied by the common auxiliary electrode, are formed in the pixel region, so that response time of a liquid crystal layer and residual images are reduced and luminance is improved, thereby improving aperture ratio and viewing angle.

A multi-domain liquid crystal display device of the present invention is an improvement over the device of the Korean Patent Application No. 1999-05587, filed by the applicant of this invention, in which at least one or more electric field induction windows and dielectric structures are formed in a plurality of specific directions in a

pixel region.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a multi-domain liquid crystal display device according to the present invention includes: first and second substrates having pixel regions; a liquid crystal layer formed between the first substrate and the second substrate; a plurality of dielectric structures formed on the first substrate at predetermined intervals; and a pixel electrode having a plurality of electric field induction windows formed to alternate with the dielectric structures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A multi-domain liquid crystal display device of the present invention will be described with reference to the accompanying drawings.

FIGS. 2a and 2b are plan views showing a unit pixel of a multi-domain liquid crystal display device according to the present invention, FIGS. 3a and 3b are sectional views showing a multi-domain liquid crystal display device, taken along lines I-I′ and II-II′ of FIG. 2b, and FIGS. 4a to 4e are sectional views showing a method for fabricating a multi-domain liquid crystal display device, taken along lines III-III′ of FIG. 2a.

As shown in the above FIGS., the multi-domain liquid crystal display device according to the present invention includes a first substrate 31, a second substrate 33, a plurality of data lines 3 and gate lines 1 formed on the first substrate lengthwise and crosswise to divide the first substrate into a plurality of pixel regions, a common auxiliary electrode 15 formed around and/or in an inner section of a pixel region on the same layer as a gate line (refer to FIG. 2a), , a thin film transistor film formed in each pixel region on the first substrate and including a gate electrode 11, a gate insulating film 35, a semiconductor layer 5, an ohmic contact layer 6, source/drain electrodes 7

and 9, a passivation film 37 is formed on an entire surface of the first substrate, and a pixel electrode 13 formed on the passivation film 37 to be connected with the drain electrode 9.

In the aspect of the present invention, at least one or more electric field induction windows 51 are formed in the pixel electrode 13. The electric field induction windows 51 are formed in a plurality of specific directions to compensate electric field formed by the common auxiliary electrode 15.

The multi-domain liquid crystal display device further includes a light-shielding layer 25, a color filter layer 23 formed on the light-shielding layer 25, a common electrode 17 formed on the color filter layer 25, and a liquid crystal layer formed between the first substrate and the second substrate. The light-shielding layer 25 is formed on the second substrate 33 to shield light leaked from the gate lines 1, the data lines 3 and the thin film transistor.

A plurality of dielectric structures 53 are formed on the second substrate in different forms. The dielectric structures 53 control the electric field together with the electric field induction windows 51. Dielectric projections (portion '(' of FIG. 2) are formed at a boundary portion of the pixel regions, their bending or corner portion, or their crossing portion so that black spots are removed. That is to say, the dielectric projections of the dielectric structures act to eliminate shadow.

To fabricate the aforementioned multi-domain liquid crystal display device, the thin film transistor consisting of the gate electrode 11, the gate insulating film 35, the semiconductor layer 5, the ohmic contact layer 6 and the source/drain electrodes 7 and 9, is formed in each pixel region of the first substrate 31. At this time, the plurality of gate lines 1 and data lines 3 are formed to divide the first substrate 31 into a plurality of pixel regions.

The gate electrode 11 and the gate lines 1 are formed in such a manner that metals such as Al, Mo, Cr, Ta, Al alloy or a dual layer formed of two of these metals, are layered by sputtering and patterned. At the same time, the common auxiliary electrode 15 is formed around and in the pixel region. The common auxiliary electrode 15 includes at least one or more electrodes in each pixel region and is electrically connected with a common auxiliary electrode of a neighboring pixel through a connecting portion (FIG. 4a).

The common auxiliary electrode 15 is formed on the same layer as the gate line 1 using one mask. The common auxiliary electrode is formed of the same material as the gate line 1 so that the common auxiliary electrode 15 is electrically connected with the common electrode 17. The common auxiliary electrode 15 may be formed of a material different from the gate line using an additional mask or different double layers.

Subsequently, the gate insulating film 35 is formed in such a manner that SiN_x or SiO_X is deposited on the gate electrode, the common auxiliary electrode and the gate line by plasma enhancement chemical vapor deposition (PECVD). The semiconductor layer 5 and the ohmic contact layer 6 are formed in such a manner that a-Si and n^+ a-Si are deposited by PECVD and patterned (FIG. 4a).

Alternatively, the gate insulating film 35 is formed in such a manner that SiN_x or SiO_X, a-Si and n^+ a-Si are successively deposited. The semiconductor layer 5 and the ohmic contact layer 6 are formed in such a manner that a-Si and n^+ a-Si are patterned. To improve aperture ratio, the gate insulating film 35 may be formed of BenzoCycloButene (BCB), acrylic resin, or polyimide compound.

Metals such as Al, Mo, Cr, Ta or Al alloy, or a dual layer formed of two of these metals, are layered by sputtering and patterned so that the data lines 3 and the source/drain electrodes 7 and 9 are formed (FIG. 4c). At this time, a storage electrode 43

is formed to overlap the gate lines 1 and/or the common auxiliary electrode 15. The storage electrode 43 acts as a storage capacitor together with the gate lines 1 and/or the common auxiliary electrode 15.

Subsequently, the passivation film 37 is formed of a material such as BCB, acrylic resin, polyimide compound, SiN_x or SiO_x on the first substrate 31. A metal such as indium tin oxide (ITO) is deposited by sputtering and patterned to form the pixel electrode 13 (FIG. 4d).

At this time, the storage electrode 43 extends to the pixel electrode 13 to overlap the pixel electrode 13, and the passivation film below the overlap portion is removed to form a contact hole 39 so that the pixel electrode 13 is electrically connected with the storage electrode 43. Also, in the same manner, the passivation film on the drain electrode 9 is selectively removed to form the contact hole 39 so that the pixel electrode 13 is connected with the drain electrode 9 through the contact hole 39 (FIG. 4e).

At the same time, at least one or-more electric field induction windows 51 are formed in a plurality of specific directions in the pixel electrode 13. The electric field induction windows act to compensate electric field formed by the common auxiliary electrode 15, thereby reducing response time of the liquid crystal display device.

In addition, an alignment film (not shown) may be formed on the pixel electrode 13.

In the embodiments according to the liquid crystal display device of the present invention, L-shaped thin film transistors having high aperture ratio are shown. The L-shaped TFT has an improved aperture ratio as compared with the related art because of its L-shape, and can reduce parasitic capacitance generated between the gate line 1 and the drain electrode 9.

As shown in FIG. 5a, the light-shielding layer 25 is formed on the second

substrate 33, and the color filter layer 23 is formed to repeat R(red), G(green) and B(blue) elements for each pixel. The common electrode 17 is formed of a transparent electrode such as ITO on the color filter layer 23, in the same manner as the pixel electrode 13. A photoresist material is deposited on the common electrode 17 and patterned by photolithography to form dielectric structures 53 having various shapes.

Additionally, the alignment film (not shown) may be formed on the dielectric structures 53.

Subsequently, a liquid crystal is injected between the first substrate 31 and the second substrate 33 so that a multi-domain liquid crystal display device is completed. The liquid crystal has a positive dielectric anisotropy or a negative dielectric anisotropy. The liquid crystal may have a chiral dopant.

Preferably, the dielectric structures 53 have dielectric constants equal to or smaller than the liquid crystal layer, and more preferably 3 or below. A material such as photoacrylate or BCB may be used as the dielectric structures.

To apply a voltage V_{com} to the common auxiliary electrode 15, an Ag-Dotting portion is formed in each corner of a driving region of the liquid crystal display device on the first substrate 31, and the electric field is applied to the second substrate 33 to drive the liquid crystal by the potential difference between upper and lower substrates. The Ag-Dotting portion of each corner is connected with the common auxiliary electrode 15. Thus, the voltage V_{com} is applied to the common auxiliary electrode 15. This process is performed when forming the common auxiliary electrode 15.

A phase difference film 29 is formed on at least one of the first substrate 31 and the second substrate 33 (see FIG. 11).

The phase difference film 29 is a negative uniaxial film having one axis and acts to compensate a viewing angle of a user. Therefore, a region having no gray inversion is

expanded, contrast ratio in incline direction increases, and a multi-domain is formed by one pixel. Thus, a viewing angle in left and right direction can effectively be compensated.

In addition to the negative uniaxial film, a negative biaxial film having two axes may be formed as the phase difference film. The negative biaxial film having two axes can obtain a viewing angle wider than the negative uniaxial film.

Furthermore, the uniaxial film 29 and the biaxial film 59 attached to each other may be formed as the phase difference film. The above structure relief users from cross drawing work during the film processing because the essential refraction difference of the film composing material is used instead. And this could embody more regular retardation Δnd than a single film.

FIGS. 11a and 11b are sectional views showing a uniaxial film (n_x= "n_y> n_z or n_x> n_y= "n_z) or a biaxial film (n_X-n_z> n_x-n_y) formed on the second substrate 33. FIGS. 11c to 11f are sectional views in which a uniaxial film or a biaxial film is formed on the first substrate and the second substrate or a uniaxial film and a biaxial film are respectively formed on the first substrate and the second substrate. FIGS. 11g and 11h are sectional views showing two uniaxial films or two biaxial films formed on the second substrate. FIGS. 11i and 11j are sectional views showing a uniaxial film or a biaxial film formed on the second substrate.

FIGS. 5a to 5c are plan views showing a multi-domain liquid crystal display device according to the first embodiment of the present invention, FIGS. 6a to6 are plan views showing a multi-domain liquid crystal display device according to the second embodiment of the present invention, FIGS. 7a to 7c are plan views showing a multi-domain liquid crystal display device according to the third embodiment of the present invention, FIGS. 8a to 8c are plan views showing a multi-domain liquid crystal display

device according to the fourth embodiment of the present invention, FIGS. 9a to 9c are plan views showing a multi-domain liquid crystal display device according to the fifth embodiment of the present invention, and FIGS. 10a to 10c are plan views showing a multi-domain liquid crystal display device according to the sixth embodiment of the present invention.

In the liquid crystal display device according to the second to fifth embodiments of the present invention, a pair of neighboring pixels, electric field induction windows and dielectric structures are shown. The electric field induction windows are patterned in zig-zag forms for dividing one pixel into three regions, and the dielectric structures are formed within three pixel regions in parallel and horizontal to the electric field induction windows. A projection or a small electric field induction window is formed at a boundary portion of the pixel regions, their bending or corner portion, or their crossing portion.

FIGS. 5b, 6b, 7b, 8b, 9b and 11b show a variety of configurations of the common auxiliary electrode 15 formed on the boundary portion of the pixel regions according to the present invention. FIGS. 5c, 6c, 7c, 8c, 9c and 11c show a variety of configurations of the common auxiliary electrode 15 formed in a region corresponding to the boundary of the three pixel regions and the electric field induction window according to the present invention.

In FIGS. 7 and 8, a fine projection is formed in the electric field induction window and acts to eliminate shadows so that a spot on the liquid crystal display device is removed. In FIGS. 9 and 10, a cut-off portion is formed in a boundary between a corner and a domain of the pixel region so that the cut-off portion acts as a shadow remover.

In the multi-domain liquid crystal display device of the present invention, the

dielectric structure 53 is formed on the pixel electrode and/or the common auxiliary electrode. Alternatively, the pixel electrode, the passivation film, the gate insulating film, the color filter layer, an overcoat layer, and/or the common electrode are patterned to form the electric field induction window 51 in the shape of a hole or slit. Thus, electric field distortion effect and the multi-domain can be realized.

The electric field induction window 51 or the dielectric structure 53 causes a multi-domain effect. Also, the electric field induction window 51 or the dielectric structure 53 may be formed on either the first substrate or the second substrate, independently or on both substrates.

Additionally, in the multi-domain liquid crystal display device of the present invention, an alignment film (not shown) is formed on the first substrate and/or the second substrate. The alignment film is formed of a material such as polyamide, polyamide-based compound, polyvinylalcohol (PVA), polyamic acid, or SiO_2. If the alignment direction is determined by rubbing, any material suitable for rubbing may be used as the alignment film.

Also, a photo-reactive material such as PVCN (polyvinylcinnamate), PSCN (polysiloxanecinnamate), or CelCN (cellulosecinnamate) may be used as the alignment film. The other materials suitable for photo-alignment may be used as the alignment film. Light is radiated onto the photo-alignment film at least one time to determine a pretilt angle and alignment direction or pretilt direction of the director of the liquid crystal molecule at the same time, thereby obtaining stable alignment of the liquid crystal. Tilt-irradiation once, or vertical tilt-irradiation twice may be performed. The light used for the photo-alignment is suitable for light in an ultraviolet region. Non-polarized light, unpolarized light, linear-polarized light or partially polarized light may be used for the photo-alignment.

The photo-alignment or rubbing is applicable to one of the first substrate and the second substrate or both substrates. Different alignment methods are applicable to both substrates. Alignment process is optional and may not be performed even after forming the alignment film.

Furthermore, the aforementioned alignment is performed to form the multi-domain liquid crystal display device divided into at least two regions. Thus, the liquid crystal molecule of the liquid crystal layer may be aligned differently on each region. In other words, each pixel is divided into four regions in + shape or x shape, or each pixel is divided in horizontal, vertical, or diagonal direction. Alignment process or alignment direction is varied depending on each region and each substrate, so that multi-domain effect can be realized. At least one region of the divided regions may be an unaligned region or all the divided regions maybe unaligned.

[EFFECT OF THE INVENTION]

As aforementioned, the multi-domain liquid crystal display device has the following advantages.

The common auxiliary electrode is formed on the same layer as the gate lines around and in the pixel region, and the electric field induction windows and the dielectric structures as well as the common auxiliary electrode are formed within the pixel region, so that response time of the liquid crystal display device is reduced and the viewing angle is improved, thereby improving the multi-domain effect.

In addition, at least one or more electric field induction windows and the dielectric structures are formed in a plurality of directions within one pixel, and the projection is additionally formed, so that residual images and disclination caused by uneven electric field can be removed.